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New Lamp Developments*

By N. L. HARRIS, B.Sc., F.Inst.P.

Synopsis

The history of electric lamp development has been one of steady improvement in the efficiency of production of light. The lamps used to-day for general lighting have 15 to 20 times the efficiency of those first developed some 70 years ago. This paper surveys recent achievements and indicates the probable lines of future developments. New types of carbon arc lamp are described. Filament lamps, on the whole, are unlikely to advance far beyond their present level of performance. Discharge lamps, however, promise considerable development in various directions. Typical of progress in fluorescent lamps is the discovery of halophosphate phosphors giving white light from a single powder, having a high degree of chemical stability and already providing an improvement of more than 50 per cent. in the average efficiency throughout life. Simplification of control gear and the rapid starting of lamps are other aspects under constant review and in which developments may be expected. High-pressure metal vapour lamps show improved colour-rendering properties, without loss of luminous efficiency, by the addition of cadmium and zinc vapours and the use of higher operating temperatures. They are already finding application in cinema and television studios and give promise of ultimate use in general lighting service. Other developments reviewed include high intensity flash discharge lamps for use in photographic studios, press photography, and similar work. The operating circuit can be adapted for using the lamps in stroboscopic examinations of moving machinery. Daylight colour matching fluorescent lamps and additions to the range of specialised discharge lamps used in laboratory work are also described.

Introduction

In looking at the present state of electric lamp development, it is well to glance at the past in order to obtain a glimpse of the future.

The history of the electric lamp has been one of steady improvement in the efficiency of production of light. The promise of increased luminous efficiency has been the chief incentive which has encouraged research and development in the past and this remains largely true to-day. Looking back, we see clearly defined phases in the history of electric lighting, each marked by the emergence of a new type of lamp. Accumulated scientific knowledge has then yielded an idea which has crystallised into a practical engineering development. Research work to improve the new lamp goes on, perhaps for many years, until this particular field is exhausted and the urge to progress further leads to research in another direction. Some advances are confined to specialised lighting applications but usually the realm of general lighting benefits from each step forward.

In retrospect the evolutionary process may seem slow. As early as the late seventeenth century, scientists were experimenting with frictional electric machines which reproduced in miniature the natural phenomena of visible atmospheric electric discharges. In 1701, Hawksbee produced a glowing electric discharge within an evacuated glass bulb. By 1744, Grummert was making

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proposals for electric lighting in mines and Winkler was showing glowing discharge tubes bent into letter form. In 1802, Sir Humphrey Davy demonstrated a glowing platinum filament, electrically heated and, a little later, the carbon arc. Yet it was not until the latter part of the nineteenth century that the first practical carbon arc lamps and incandescent carbon filament lamps emerged for general use. (1)

Progress since then has been varied and extensive. The carbon arc as a general illuminant was completely ousted by filament lamps of increasing watts, efficiency and reliability, and was itself relegated to specialist uses. There was renewed interest in the electrical discharge, as an illuminant, in the first place a high voltage type mostly used for display. Later, with the introduction of activated electrodes, the discharge lamp was operated at mains voltage and began to be used for certain classes of general lighting. Then followed a period of intense research on luminescent phosphors which has yielded a range of discharge lamps which is replacing the incandescent filament types for many purposes. Other discharge lamp developments rival the carbon arc as sources of high intrinsic brightness.

Throughout these active seventy years of development the luminous efficiency of lamps used for general lighting has increased some fifteen to twenty times and there has been steady improvement in the life performance of all kinds of lamps. In addition to developments of the lamps themselves, there has been a parallel growth of understanding of the functional requirements of electric lighting. Lamp designers and illuminating engineers have worked together to adapt lamps and fittings in the solution of the many problems involved in the efficient direction of the light.

With this background picture it is possible to consider the present position in lamp development and what future possibilities lie ahead.

The Carbon Arc

Although for many years the use of the carbon arc has been largely restricted to the projection and cinema studio field, arc lamp design has been far from static. The war brought fresh demands for more and more powerful arc lamps with ever greater beam intensities. The two outstanding developments were a ground searchlight using an arc lamp of 600 kw. consumption (the largest artificial light source ever made) (2) and the air-borne Turbinlite, a 140-kw. arc light operated from lead-acid batteries.(2)

Extensive use is made of the arc lamp in the cinematograph industry both for projection and for studio lighting. A recent advance(3) of considerable importance in connection with the latter has been the introduction of the double-negative carbon arc lamp for use where silent operation is essential. It is a 150-amp. high intensity arc, and the use of the two negatives, besides decreasing considerably the amount of noise inherent in the arc, reduces the voltage drop across it from 65 to 48 volts. It is thus possible to run two such arcs in series from the 115-volt studio mains and to obtain the illumination needed on the studio floor with half the power previously required.

A projection arc development of great value where large screens have to be lit or high screen brightness is required (as in back-projection work in studios) is one in which water-cooled jaws are fitted for leading the current into the positive carbon, very close to the arc. With this arrangement very high current density can be employed with a resulting increase in brightness of the positive crater. The current through a positive 13.6 mm. in diameter can, by this means, be increased from a normal value of 140 amps. to 290 amps., and at the same time the mean crater brightness is doubled.

Incandescent Filament Lamps

In many years of research on incandescent filament lamps, an extremely wide field of work has been covered and finality in design is nearly reached. The historical trend of development has been the search for more refractory materials for the filaments so that these could be operated at higher temperatures, producing higher luminous efficiencies, without shortening the life of the lamp through excessive filament evaporation. In turn, carbon, the refractory oxide of the Nernst filament, and the metals tantalum and osmium were used before the technique of making squirted and, later, drawn tungsten wire was evolved and the use of this latter material became almost universal. Each step brought an improvement in luminous efficiency (Fig. 1). A further big improvement was then made by coiling the filament into a close spiral and operating it in a neutral gaseous atmosphere. In this way the operating temperature was still further increased without raising the rate of evaporation

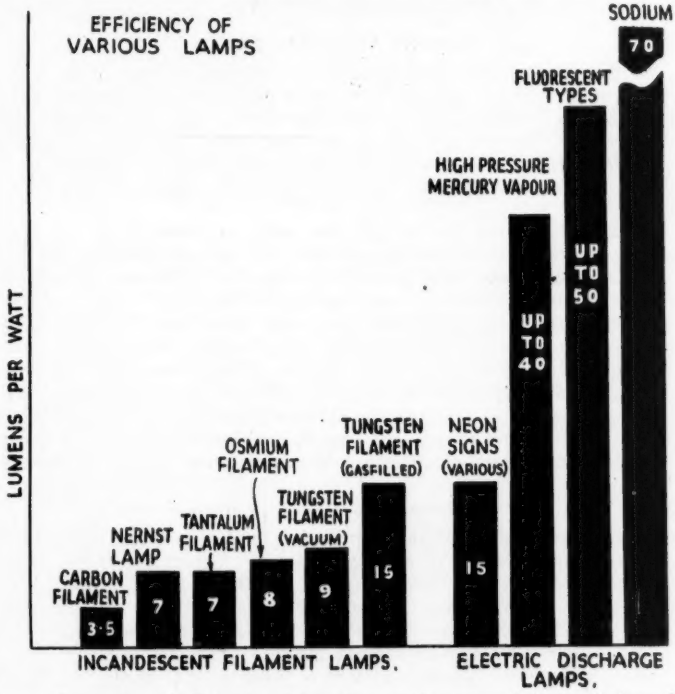


Fig. 1. Comparison of efficiencies of incandescent filament and electric discharge lamps.

of metal. By a second coiling of the spiral filament, the same operating temperature was obtained in the lower ratings of lamp with some ten to twenty per cent. saving in watts and a corresponding increase in efficiency.

For the past ten years or more no major advances have taken place, although there have been improvements in design, particularly in projector lamps.(4) There seems little prospect of finding a more refractory material than tungsten. Further economy in the watts required to reach the normal

operating temperature is theoretically possible by triple coiling of the tungsten filament, but this is technically impracticable. Substitution of the rare gas krypton for the normal argon filling of the lamp makes a five to twenty per cent., or more, improvement feasible, and xenon would give a further small increase. Krypton had been used successfully before the war in the small miners' lamps where the utmost luminous efficiency is desirable and, although unused during the war, has now been re-introduced. It is too expensive a solution for ordinary general lighting service lamps at present, but should ample supplies of cheap krypton ever become available, then the change will no doubt be made.

It seems clear, however, that the only improvements which can be expected in filament lamps, generally speaking, are those minor ones which accumulate as manufacturing experience extends, and an increasingly closer control of the product is obtained. Technical improvements made in this way may permit small increases in efficiency from time to time.

Electric Discharge Lamps

In sharp contrast to the incandescent filament lamp field, the electric discharge lamp territory is by no means fully explored, and there is still promise of considerable improvement in various directions. It is historically interesting that the electrical discharge, which was the first source of artificial light generated electrically, and which was left comparatively undeveloped in the early phases of electric lighting, should now be the latest subject for intensive research.

The decade preceding the recent war saw the emergence of various new types of discharge lamp which opened up fresh possibilities in the cheap and efficient lighting of streets and industrial premises. Various factors, including selective colour rendering, slow running up to full light output and delay in re-starting after switching off, made the lamps unsuitable for general illumination purposes. In parallel with these, high voltage fluorescent tubes were developed, which led directly to the tubular fluorescent lamp. This made its appearance in the early days of the war and has been increasingly used for general lighting ever since. Of all the types of discharge lamp which have been developed this is the one which, because of its high efficiency and the pleasing quality of its light, offers the keenest rivalry to the tungsten filament lamp to-day.

Tubular Fluorescent Lamps

The success of tubular fluorescent lamps has depended upon three main factors, (i) the development of new and highly efficient luminescent materials (now usually referred to as "phosphors"), (ii) the successful designing of low-pressure mercury vapour lamps in comparatively low watt ratings with a high efficiency of generation of ultra-violet radiation, and (iii) the solution of associated control circuit problems in simple terms[5].

Of these factors, the successful use of luminescent materials is the vital feature which has made the lamps suitable for general lighting where a pleasing rendering of colours is essential. The development of new phosphors of high efficiency has been the key to the very high luminous efficiencies which have been achieved. Their development has the familiar feature of many modern scientific achievements—it has its beginnings in ancient history, but its recent advance and successful application cover a mere decade or so of intensive research.

Phosphors can be described as "frequency-changers" for electro-magnetic waves. The change always involves a reduction in frequency, so by their use

invisible ultra-violet radiation (which is often produced abundantly in the electric discharge) is converted to visible radiation of lower frequency and correspondingly longer wavelength. If the substance ceases to glow immediately after the irradiation is stopped, it is said to be "fluorescent." If the glow fades away slowly, the term "phosphorescent" is applied, but the former term is often used loosely for both types of phenomenon. The slow decay of the phosphorescent material can be used to minimise the stroboscopic "flicker" effect. This latter is sometimes more apparent in discharge lamps (operating on a.c. supplies) than in tungsten filament lamps, where the heat capacity of the filament tends to reduce the effect.

The fluorescent lamp itself, in essence, is a low-pressure mercury vapour discharge lamp on the walls of which a phosphor, or mixture of phosphors, has been applied. Improvement of lamp performance can come from increased efficiency in the generation of ultra-violet radiation by the discharge as well as from improvements in the efficiency of conversion of this invisible radiation to visible light by the phosphors.

It may be that we are nearing finality in lamp design so far as the low-pressure mercury discharge is concerned, but it is possible that a more efficient generator of suitable ultra-violet radiation will be developed. In the mercury discharge, the "resonance line" radiation at 2,537 A.U. and other radiation at shorter wavelengths are particularly effective and, in suitable conditions, some 60 per cent. of the energy in the discharge column is radiated in this way. Only about 1½ per cent. is radiated as light and the remainder is accounted for by heat losses.

This high efficiency of generation of ultra-violet radiation is dependent upon the pressure of mercury vapour (and, therefore, upon the wall temperature of the lamp) and on the current density. The optimum pressure is approximately 0.005 mm. of mercury, which corresponds to wall temperatures of the order of 40 deg. C. This is a value which fits in well with other considerations of lamp design and operation. The auxiliary filling of argon at a few mms. pressure which is used to facilitate the starting of the discharge has little effect on the ultra-violet radiation generated.

So far as current density is concerned, the efficiency of generation of the short wavelength ultra-violet radiation continues to increase as the current density is decreased to very low values. This is only true providing the mercury vapour pressure is maintained at the optimum value. In practice the power dissipated in the tube is relied on to maintain the correct operating temperature. If the tube current is reduced excessively efficient generation of ultra-violet radiation is impossible, in spite of the low current density, simply because the tube is too cold.

The working compromise which has been adopted between requirements for the optimum production of ultra-violet radiation and adequately high watts dissipation and light output gives a satisfactory performance.

Further questions of efficient design arise when the lengths and diameters of the tubes have to be decided. The longer the lamp the smaller is the proportional wasteful loss of electrical energy at the electrodes themselves. The length must not, however, exceed a value which involves a tube voltage greater than some 60 per cent. of the mains voltage, or unstable operation results. Lamp diameter is involved in this calculation also, and this affects tube brightness. Again, a working compromise must be made, and, fortunately, this can be done without serious disadvantage in any direction. The full projected range of lamps which has been based on considerations such as the

above is likely to form the basis of fluorescent tube design for some time to come.

Clearly, then, substantial developments in fluorescent lamp performance depend upon improvements in the phosphors, and here much has been accomplished since the first introduction of the lamps. There is promise of further improvement to come.

It should be remembered that, whilst the luminescent properties of some natural minerals, certain dyestuffs, organic substances, and mineral oils have been known for a long time, it was the successful development of certain inorganic luminescent salts, prepared in the laboratory, which made possible the modern fluorescent lamp. For their preparation very pure chemicals must be used, and, after the addition of small amounts of a metal "activator" (often only a fraction of one per cent.), treatment in a high temperature furnace produces particular crystalline forms. The finished phosphor must be ground to the correct grade of fine powder, so that it can be mixed with a "binder" fluid and applied to the inside of the lamp. The coating is then dried and the binder removed by heating.

The manner in which phosphors produce light under ultra-violet stimulation is complex and not yet fully understood. There is little doubt that molecules of the "activators" form a pattern of "islands" in the parent crystals, and each particular arrangement has a characteristic series of energy levels associated with it. The action of ultra-violet radiation is to move electrons inside the crystal structure amongst these energy levels, and light is emitted when they return to their normal state. The energy levels are broad, and the light is emitted over a correspondingly broad band of colour, instead of at particular wavelengths, as it would be in the case of an electric discharge in a gas or vapour.

This subject offers a very wide field for research, and it has already proved a

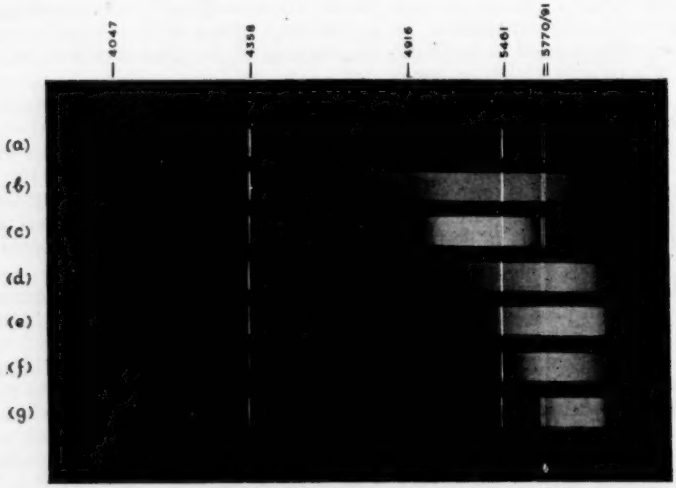


Fig. 2. Spectra of phosphors.

(a) calcium tungstate.
(b) magnesium tungstate.
(c) zinc silicate.
(d) and (e) zinc beryllium silicate.
(f) cadmium chlorophosphate.
(g) cadmium borate.

useful one. Amongst the phosphors which were first developed were the sulphides of zinc and cadmium, silicates of zinc and beryllium, cadmium borate, and magnesium tungstate. The usual activators were silver, copper, and manganese. By itself each of these phosphors gave a coloured luminescence (Fig. 2), but careful choice and mixing of a number of them gave the complete range of colours required to imitate daylight and to provide a modified white light of warmer or colder hue as was desired (Fig 3).

Research on new families of chemical compounds with luminescent pro-

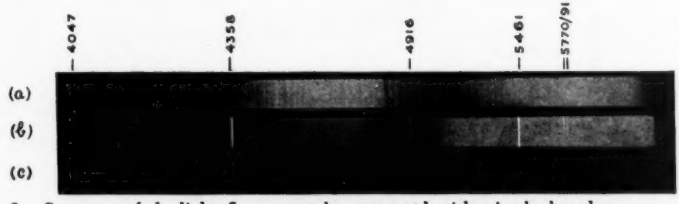


Fig. 3. Spectrum of daylight fluorescent lamp, coated with mixed phosphors, compared with that of noon sunlight.

(a) Spectrum of noon sunlight.
(b) Spectrum of daylight fluorescent lamp.
(c) Spectrum of similar lamp (uncoated).

perties is constantly in progress, and an important advance was made recently in the discovery of a range of halophosphate compounds (6). Their crystal structure is like that of the mineral Apatite $3Ca_3(PO_4)_2.1Ca(F,Cl)_2$, and the matrix is activated primarily by antimony, which gives a pale blue fluorescence. If manganese is added as a secondary activator the peak of emission is moved through the spectrum towards the red end.

These new phosphors are not only highly efficient converters of ultra-violet radiation to visible light but also possess the valuable property of providing, in themselves, white light of spectral quality similar to black-body emitters. There is, therefore, no necessity to blend several powders when making up the coatings for the lamps and a closer control of the colour of the light is possible (Fig. 4).

Another advantage whch they possess is apparent when the depreciation of efficiency during the life of the lamp is studied. Interaction between elec-

Fig. 4. Spectrum of calcium halophosphate phosphor giving a warm white colour. (The difference between this and the spectrum photograph of the daylight colour powder is too small to show clearly in reproduction.)

trically excited atoms of mercury and the surfaces of crystals exposed to the discharge is a major cause of depreciation in the light output of the lamp. A minor factor is the deposition of metallic mercury and of material evaporated from the electrodes on the luminescent coating. Such effects (which are not yet fully understood) are responsible for the initial fall in light output of some

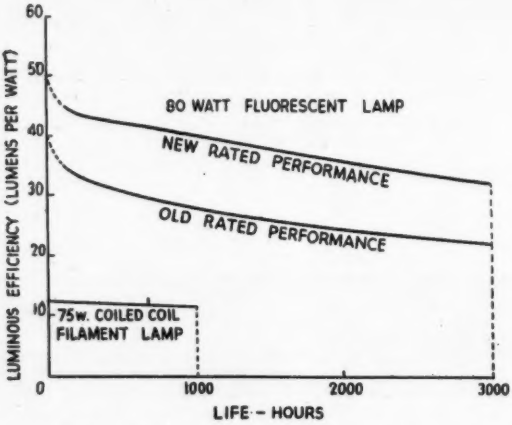


Fig. 5. Efficiency-life relationships of 80-watt fluorescent lamps.

10 per cent. in the first 100 hours and the subsequent much slower rate of fall during the remainder of the lamp's life.

The new halophosphate powders give such an improved performance in these respects when compared with earlier powder mixtures that for 80-watt daylight fluorescent lamps an increase of over 50 per cent. in the objective average luminous efficiency throughout life has been made. The greater part of this improvement is due to the new phosphors (Fig. 5).

Before leaving the subject of phosphors, mention should be made of the development of daylight colour-matching fluorescent lamps, in which the phosphor is carefully blended to match the spectral quality of the light from an overcast north sky. These are cold cathode lamps with an initial luminous efficiency somewhat lower than that obtained with hot cathodes, but, nevertheless, some 20 times that of the older carbon dioxide colour-matching lamp.

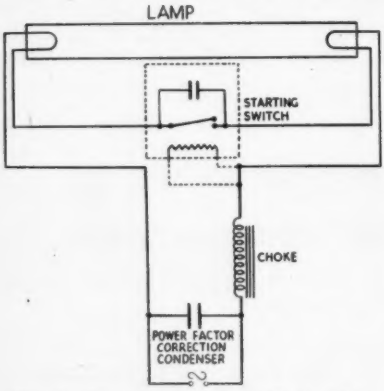


Fig. 6. Fluorescent lamp circuit with starter switch.

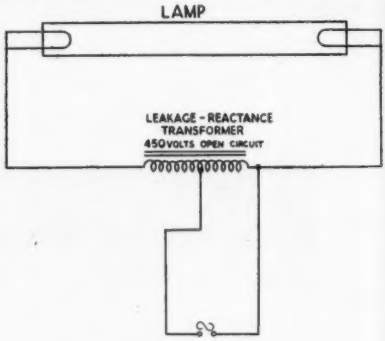


Fig. 7. Cold starting circuit with leakage reactance transformer.

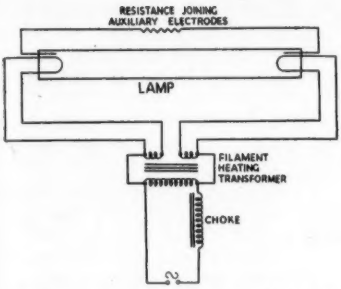
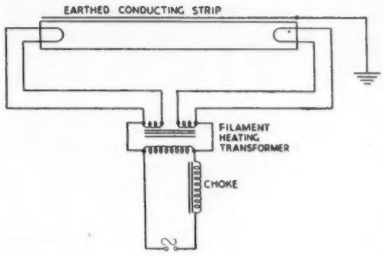


Fig. 8. (a) Auxiliary electrode circuit.



(b) Circuit with earthed starting strip.

They operate at relatively low current densities, and, because of this, lumen maintenance is improved and negligible colour distortion effects due to emission by the mercury discharge itself occur. These two factors are of the utmost importance in this type of lamp. There is no technical difficulty in producing this colour in a mains voltage lamp, where the higher luminous efficiency may offset the advantages of long life and good colour stability of the cold cathode source.

Fluorescent Lamp Circuits

The normal fluorescent lamp circuit employing a choke and starting switch (Fig. 6) is too well known to need further description here. It involves a delay of a few seconds between the switching on of the lamp and its actual lighting. Although this delay is usually of little importance, there are some applications in which it is a disadvantage and a quick-starting circuit is called for. In the U.S.A. a solution has been found by stepping-up the normal mains voltage to 400 to 500 volts. At this voltage the lamps start without pre-heating of the electrodes, just as is the case with the familiar sodium lamp circuit in this country (Fig. 7).

Such a scheme meets only with qualified approval here on account of the high voltages which are required and the special design of electrode necessary to withstand the cold starting.

Another method of obtaining quick starting is to heat the electrodes independently by means of a special transformer. The ordinary mains voltage is then often sufficient to start the discharge without further complication, but to ensure starting in adverse atmospheric conditions or on low mains voltage, some form of auxiliary electrode system is desirable. An old and well-established system of this nature, shown in Fig. 8(a), was formerly used in floodlighting tube circuits.

To avoid the complication and expense involved in fitting extra electrodes inside the lamp some form of external auxiliary electrode in the form of an earthed conducting strip on the lamp itself may be desirable (Fig. 8(b)).

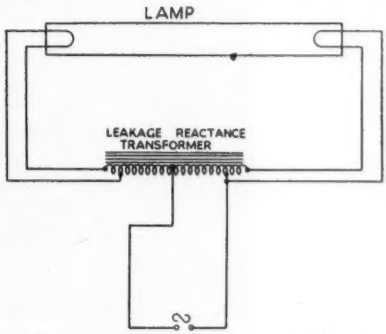


Fig. 9. Circuit with leakage-reactance transformer and cathode heating.

It is, of course, well known that an earthed conductor near to the lamp facilitates starting, but for a lamp with a tube voltage as high as that of the 5-ft. 80-watt lamp it is probable that more effective earthing of the lamp envelope is desirable to ensure starting in adverse supply voltage or atmospheric conditions.

There are a number of obvious variations of such circuits; for example, the choke and cathode heating transformer may be combined in a leakage reactance type of transformer with separate cathode heating windings (Fig. 9).

It should be noted that the additional cost of providing cathode heating by means such as the above is to some extent, at least, offset by the saving obtained from elimination of the starter switch.

High-Pressure Metal Vapour Discharge Lamps

When mains voltage discharge lamps first made their public appearance in 1932 two outstanding types were the high-pressure mercury vapour lamp and the sodium vapour lamp. Both types found ready application in specialised street and industrial lighting fields because of their high luminous efficiency and in spite of the colour of the light emitted. The sodium lamp, yielding a nearly monochromatic yellow colour soon reached a stage of development where luminous efficiencies exceeding 70 lumens per watt were obtained in ratings of 140 watts or less. There has been no large increase in the efficiency of sodium lamps since then, although, as with all other types, steady improvements

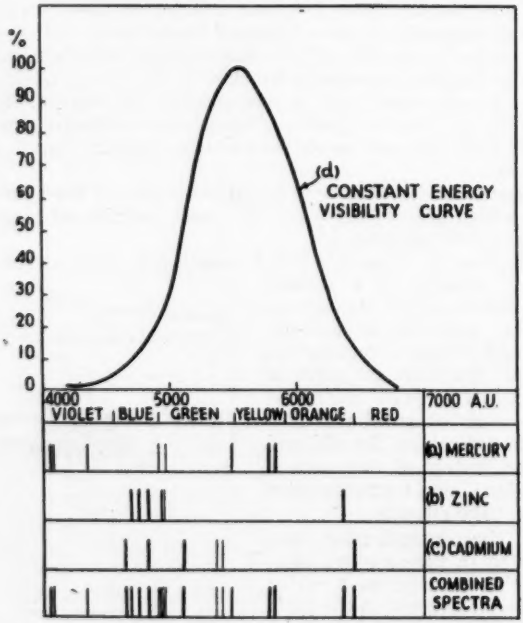


Fig. 10. Spectral distribution of light from mercury vapour arc with added zinc and cadmium vapours.

in lamp life and average performance have been secured. So far as can be judged, the sodium lamp has reached finality in design.

The high-pressure mercury vapour lamp, with an efficiency somewhat over 40 lumens per watt, in a 400-watt rating, started with the advantage of greater light output and better colour-rendering properties, but was deficient in red radiation. Due to the high pressure of mercury vapour developed in the lamp a continuous background appeared in its spectrum and contributed to the improvement in colour in comparison with earlier forms of mercury lamp. Means were found of maintaining these high pressures and correspondingly high luminous efficiencies in ratings down to 80 watts. Some further improvement in the red content of the light emitted was obtained by the addition of cadmium to the filling and the use of luminescent zinc sulphide coatings on the inner wall of the outer jacket of the lamp. The best colour obtained, however, by such means never approached that of the modern low pressure tubular fluorescent lamp.

A further feature of high-pressure mercury lamp development was the use of a highly concentrated discharge column as a very high brightness source for projection work. Both linear and compact source types were developed, some of which employed water cooling and, with operating pressures greatly in excess of atmospheric, brightness values exceeding that of the carbon arc were obtained.

Theoretical and practical work indicates clearly that there is an apparent upper limit to the luminous efficiency of the mercury vapour discharge of the order of 80 lumens per watt. Although lamps available commercially have so far not exceeded 40 to 50 lumens per watt there is reason to suggest that ultimately lamps of efficiencies up to 75 lumens per watt may be produced.(7) The lighting engineer will find interest in the fact that the arc length of such lamps is likely to be only a centimetre or so.

Recent work on high-pressure metal vapour discharge lamps has produced some striking advances in the results obtained when zinc and cadmium vapours are added to the mercury filling.(8) It was found that if the operating pressure of the auxiliary vapours can be increased sufficiently by operating the lamps at much higher temperatures then a substantial improvement in colour results. In the past the widespread use of glass for the inner lamp envelopes has restricted the lamp operating temperature. The vapour pressure of the zinc or cadmium additives was, therefore, low and the small improvement in colour

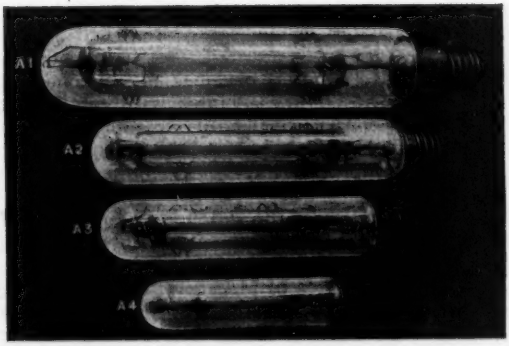
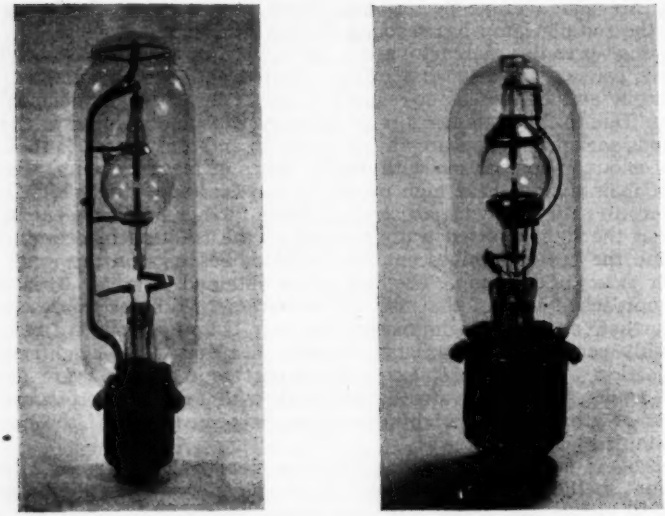


Fig. 11. High-pressure mercury vapour lamps.
(A1) 650-watt. (A2) 400-watt.
(A3) 250 watt. (A4) 150-watt.



(a) (b)

Fig. 12. Compact source mercury vapour lamps.
(a) 500-watt. (b) 250-watt.

obtained was often at the expense of luminous efficiency. Recent developments in the use of quartz for the lamp bodies and the solution of problems arising in the sealing of the electric leads through the quartz walls have raised the upper limit of operating temperature to a value where zinc and cadmium vapour pressures of several atmospheres can be obtained. At these pressures the luminous efficiency of the zinc and cadmium discharge increases significantly and in a mixture of mercury, zinc and cadmium vapours the two latter constituents make a relatively large contribution to the luminous efficiency and the colour rendering properties of the lamp (Fig. 10). The improved colour arises from a judicious proportioning of the vapours so that gaps at both the blue and the red ends of the spectrum are filled, the correct relative energy balance to give a white colour being preserved as nearly as possible. In addition, greatly increased total pressures are used and in these conditions the continuous background radiation becomes much enhanced. Further, the glowing tips of the electrodes in these lamps with compact forms of electric discharge may themselves contribute usefully to the red end of the spectrum. All these factors contribute to the colour improvement which is obtained.

So far these new developments have been applied principally to types of lamp designed for applications where luminous efficiency is not necessarily the sole criterion of value, but from the following description of what has been accomplished already it will be seen that more general uses of the lamps are possible.

Fig. 11 shows the familiar types of MA mercury vapour lamps in ratings of 650 to 150 watts, with glass envelopes, and in which operating pressures do not greatly exceed one atmosphere. Fig. 12 illustrates compact source high brightness types of ME lamp of similar ratings with quartz envelopes which had been developed prior to 1939. In these types a peak brightness of some 20,000

stilb was achieved. (Brightness is measured in candles per square centimetre of radiating surface or discharge column. One stilb is equivalent to one candle per square centimetre.) Table 1 indicates the relative brightness of various well-known sources.

Table 1

Source	Brightness
Tungsten filament lamps	Up to 2,000 stilb.
Carbon arc (plain carbons)	10,000 to 25,000 stilb.
Carbon arc (High intensity)	50,000 to 100,000 stilb.
Mercury vapour arc, type MA lamps ...	Up to 150 stilb.
Compact source mercury vapour arc, lower wattage ratings	Up to 20,000 stilb.
Ditto, higher wattage ratings	Up to 200,000 stilb.
The Sun	180,000 stilb.

During the war the wattage rating and the arc brightness of these lamps were both increased by a large factor. In succession experimental lamps of 5 kw., 10 kw., 15 kw., and 25 kw. were produced, and finally a design of 50-kw.

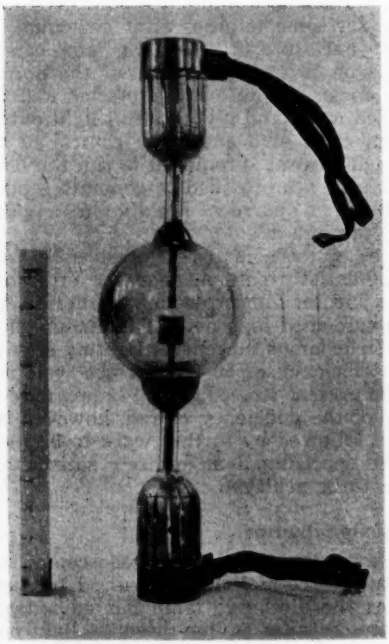


Fig. 13. 25-kw. mercury vapour arc lamp.

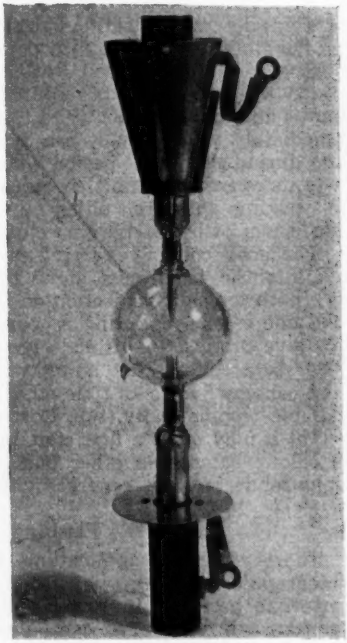


Fig. 14. 2½-kw. mercury-cadmium compact source lamp.

lamp was tried. These lamps were designed for projection work where their simplicity and cleanliness in operation offered advantages over the high current density arc. Fig. 13 shows the 25-kw. D.C. lamp in which an operating pressure of five atmospheres was employed and a brightness of about 100,000 stilb achieved.

The elaboration of the simple molybdenum foil strip seal of the early forms of type ME lamp (Fig. 12) into the multi-strip type, capable of carrying some 300 amps. continuously through the quartz wall, is apparent.

The techniques which were worked out in these developments and the experience gained during the war have been profitably employed in the post-war developments involving the addition of other metal vapours to obtain colour improvement. The first such developments (Fig. 14) were the 2½-kw. and 5-kw. lamps adapted for use as floodlights and spotlights in the lighting of cinema studio sets for colour film photography and for television studios.(9) The colour rendering of the light emitted is satisfactory for this purpose. The high efficiency of the lamp (some 40 to 50 lumens per watt), together with the concentration of its heat radiation in the long wavelength part of the infra-red spectrum, allows the very high levels of illumination required to be obtained without that excessive discomfort to the actors which is inevitable when other types of illuminant are used. The silent operation necessary for sound film work is also secured.

Some interesting lamp circuit engineering developments have been necessary in the design of this equipment. A particular requirement for film studio use is that the lamp shall switch on instantaneously. A metal vapour lamp does not normally reach its full light output for some minutes after switching on. The floodlight, therefore, incorporates an enclosure in which the lamp can be "simmered" at a reduced wattage of some 20 to 50 per cent. of the normal rating. When its light is required, the enclosing shutters are opened and the lamp is automatically switched to its rated watts and gives its full light output immediately. The circuit can be arranged to give automatic control of the lamp during the initial period when a high current is required to run the lamp up to its operating condition quickly. Means are provided to generate a pulse for striking the arc, either by breaking a current rapidly in a pulse transformer or by discharging a capacity through it.

The good colour rendering properties of these lamps together with their high intrinsic brightness make them potentially suitable also for projection work both for back-projection on the set and for film projection in the theatre. The same colour rendering properties obtained at high overall luminous efficiency give promise of ultimate uses for such lamps in general lighting service.

It seems likely that lamps with an efficiency of 50 lumens per watt and a red content five to 10 times that of the present street-lighting lamps may be available commercially.(10) Correction of the deficiency of red, however important it may be as a first step, must be followed by further work to improve the colour balance in other parts of the spectrum if an entirely satisfactory colour rendering for general lighting is to be achieved.

Flashing Discharge Lamps

There are some applications (for example signalling, stroboscopic and photographic lamps) in which a powerful source of light is required for very short time periods. In such applications the discharge lamp has advantages over tungsten filament or carbon arc lamps because, unlike these, its light output follows lamp current variations almost instantaneously. Circuits have been devised for flashing operation of the compact source mercury vapour

lamps, and other developments followed the realisation that the rare gases (without the use of mercury vapour) are highly efficient when pulses of high current density and short duration are used. This work was pioneered by Edgerton in the U.S.A.(11)

Krypton and xenon are particularly useful in this respect, and both gases are now used commercially. A typical flash discharge lamp (Fig. 15) employs a circuit in which a capacity of about 150 microfarads is charged to 2,000 volts and then discharged through the lamp. A flash of some 150 microseconds results (measured to half-brightness values), and its peak light flux may be as high as 40 million lumens. Units of approximately this rating have recently appeared in this country for photographic studio work.

For the examination of fast-moving machinery the circuit can be arranged to operate at frequencies up to some 1,000 per second, with flashes down to three microseconds duration or less, and often bright enough for the lamp to be effective in a normally lighted room.

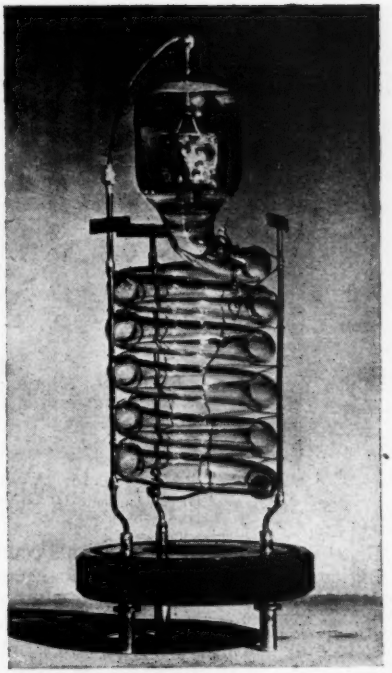


Fig. 15. High speed flash discharge tube for photographic use. (Glass outer cover removed.)

For Press photography and similar work, compact portable flash discharge equipment of light weight and simple in operation has been developed. It derives its power from built-in batteries and allows the photographer to obtain cheaply a large number of consecutive flashes whilst avoiding the inconvenience of constant replacement of the well-known photographic flash bulbs.

It has been known for many years(12) that like mercury vapour, permanent gases are capable of high luminous efficiency under steady running conditions at high current densities. More recently, what may prove to be a practical form of lamp has been evolved, and a xenon filled lamp has been demonstrated(13) in which 10 kw. is dissipated in a water-cooled quartz tube some 20 cms. long and 2 cms. diameter. The xenon spark spectrum is dominated by a continuous background of visible radiation, and an intense white light results which gives excellent rendering of colours.

Laboratory Lamps

Extensive use of many types of small discharge lamps has been made in the laboratory where a convenient source of some particular spectral quality of radiation is frequently required. Ordinary commercial lamps may often be adapted to this, but in several instances special types like the familiar sodium laboratory lamp have been designed to give a small, low wattage source usually employing a low pressure discharge for the sake of spectral purity.

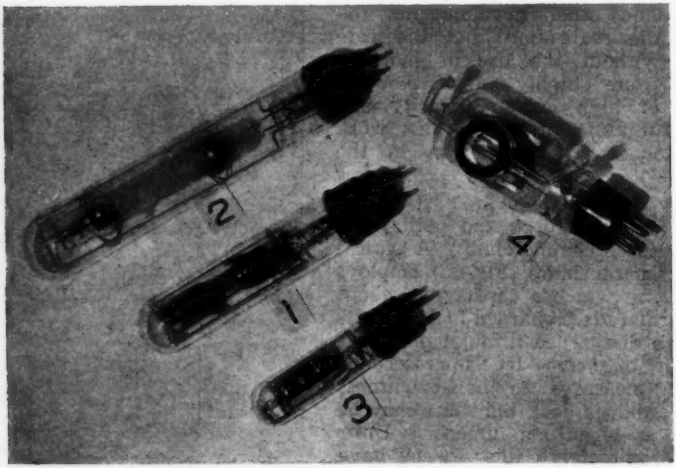


Fig. 16. A group of laboratory lamps.
(1) Sodium lamp. (2) Low-pressure mercury or cadmium lamp.
(3) Thallium lamp. (4) High intensity hydrogen arc discharge lamp.

Recent additions to these in this country have been small thallium lamps yielding an intense monochromatic green radiation and a covenient form of low pressure krypton lamp for interferometer work.

A new form of high intensity hydrogen arc-discharge lamp for use as a source of continuous ultra-violet radiation in absorption spectroscopy has also appeared. The discharge is constricted by a narrow "gate" to give the required high brightness and a crystal-quartz window transmits radiation down to about 1,800 A.U. Fig. 16 shows a group of these laboratory lamps.

It is probable that work on the artificial production of the separate isotopes of various elements may bring fresh requirements for laboratory discharge lamps embodying these and yielding radiation of particularly high spectral purity for various scientific investigations.

Conclusion

This survey has attempted to cover the major new lamp developments which are coming to fruition at present, and to indicate the lines on which further improvements may be expected. The research work of to-day has been reviewed in perspective with the past 70 years' history of electric lighting, and this, in turn, with the advance of fundamental scientific knowledge. The major developments are likely to continue in the fields of fluorescence and the high-pressure metal vapour discharge, but entirely fresh fields may be opened at any time with the crystallisation of a new scientific idea.

The constant search for improved light sources of greater efficiency has considerable economic importance in the present critical times. This may well excuse the repetition of certain figures which have been given elsewhere. The great increases made in luminous efficiency of electric lamps imply that if the present level of electric lighting had to be supplied from carbon filament lamps the country would need about five and a half million tons of coal per annum more than is used for modern lighting. An actual saving of a million tons of coal per annum is within sight if the present commercial and indus-

trial lighting loads only are converted to the same level of fluorescent lighting. This would conserve power plant by the equivalent of a 300,000 kw. power station (i.e., a generating unit the size of the Battersea station).

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(2) W. Helmore, H. K. Cameron, F. S. Hawkins, L. B. W. Jolley, and L. M. King-Brewster, Symposium on Searchlights (I.E.S.), 1948, pp. 36 and 39.

(3) W. R. Stevens and F. S. Hawkins, Journ. of the Brit. Kinem. Soc., 1947, vol. 10, p. 11.

(4) J. N. Aldington, Trans. I.E.S., 1945, vol. 10, p. 1.

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(8) L. J. Davies, Proc. of the Convention of the I.E.S., May, 1946, p. 31.
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(10) V. J. Francis and W. R. Stevens, Journ. Inst. Elect. Eng., Oct., 1947, vol. 94, p. 423.

(11) See, for example, H. E. Edgerton, Journ. Opt. Soc. of America, 1946, vol. 36, p. 390.

(12) British Patents, 482,070, 488,471.

(13) J. N. Aldington, Light and Lighting. Nov., 1947, vol. 40, p. 193.

Discussion

Dr. J. N. ALDINGTON said that in view of the shortness of time he would confine his remarks to one or two broad considerations arising out of the paper. The light source was the primary tool of the members of the Society. Notwithstanding the fact that among the members of the Society there were some eminent in the use of natural daylight, he maintained that the Society was principally concerned with lighting by artificial sources and it was a good thing that there should be broad surveys of this nature from time to time. He himself was always fascinated in listening to accounts which put in broad perspective, and against some historical background, the developments which were proceeding to-day, for a study of the history of his science was just as necessary to the research worker as the study of the history of politics was to the politician. In looking at this subject in the manner indicated by the author it was possible to see the related characteristics of the various sources and thus be enabled to select the best source for a particular job of work. Sometimes the lighting engineer was misled in selecting the wrong source for a particular job and that did not help either himself or the lamp research engineer. He therefore urged the lighting engineer, remembering the tremendous amount of work necessary to bring about each improvement in lamp efficiency, to seek by all possible means to effect the maximum utilisation of the light emitted by the source. There was a tendency to think in terms of, say, 50 per cent. or 60 per cent.

for the coefficient of utilisation but the lamp research worker was glad to improve the efficiency of these sources by perhaps steps of 2 or 3 per cent. from time to time. Mr. Ward Harrison would probably agree to the complete elimination of his coefficient of utilisation if it could be increased to unity! In conclusion, Dr. Aldington expressed the view that by constantly resurveying existing knowledge of a subject of this nature it was possible to see where further extensions could be achieved either by the application of new techniques or by the use of new materials or by the re-examination of old problems in the light of more recently acquired knowledge.

Mr. F. X. ALGAR said he understood it was more or less standard practice in America to use compensators in the control circuit of the ordinary fluorescent lamp, the advantage being quicker starting. That practice was not followed in this country because, he believed, it was thought that the advantage did not justify the extra cost involved.

Mr. HOWARD LONG (*communicated*): The author rightly points out that there is a large scope for development of the electric discharge lamps of all types, which, of course, include fluorescent lamps. Considerable developments have already taken place, with the work done in the laboratory, and the experience gained in practice. This form of lighting may now be considered quite a practical proposition if due care is taken in planning the installation.

Further simplification of control circuits is desirable, and it is not clear why the type of circuit shown in Fig. 8b or Fig. 9 has not become more popular. Not only are these more simple, but they have the advantage of instant start, etc.

In connection with Fig. 4, the author states that these new phosphors have the "property of providing, in themselves, white light of spectral quality similar to black-body emitters." In Fig. 4 the lines at 4047, 4358, 4916, 5461, and 5770/91 are shown, and these cannot be ignored. There has been considerable effort to suppress their existence, and many are ignorant that they are there. This has given rise to considerable disappointment in some applications of these lamps, whereas if the existence of these lines is appreciated, and the matter dealt with accordingly, considerable satisfaction can result.

Mr. W. J. VINE (*communicated*): The author in his opening remarks referred to the fact that between the time of preparing the paper and delivering it at the meeting, certain developments in connection with fluorescent lighting had taken place. This is certainly true, and one such development which is already available to the public is the introduction of series burning fluorescent tubes. Whilst this in itself is not new, the use of an auto-transformer for starting which uses pre-heated electrode start in conjunction with earth capacitance, offers material advantages for the series circuit. Such an arrangement ensures that the two tubes strike up more nearly simultaneously; it reduces the difficulty experienced in maintenance since starter lamps are entirely eliminated, leaving the fluorescent tubes only to be checked in the event of a failure. In addition to quick starting, the circuit operates satisfactorily on low voltages.

Such a circuit is now in use on many installations with ordinary 80-watt fluorescent tubes, striking up at approximately 185 volts and, once the tubes are alight, remaining in operation on voltages down to as low as 165 volts.

I agree with Mr. Harris that, under conditions of humidity, trouble can be experienced with this circuit, but this could be overcome by arranging for a metallised strip on the external envelope of the lamp itself. This, how-

ever, would only operate satisfactorily on the longer tubes, since, with a shorter tube, a phenomenon which is termed a "creeping start" is experienced. This is due to the earth capacitance effect tending to strike the arc before the filaments are properly pre-heated, which has a correspondingly adverse effect upon the life of the tube.

In the illustration shown by the author he had indicated that an earthed frame should be near the tube, either in the form of the fitting, or using a metallised strip on the lamp itself, as referred to above, but frequently it is not possible in practice to obtain an earth, particularly when dealing with a fully insulated wiring system. In such cases as these, it has been found that this quick-starting device functions in a proper manner with an artificial earth provided by connecting the body of the fitting through a high resistance in series with a small condenser to the neutral of the supply system.

The AUTHOR, in reply to the discussion, said: With regard to Mr. Algar's remarks, the purpose of a compensator is to increase the starting, or filament heating current in lamps having compacitative ballast. This reduces any tendency to premature ("cold") starting which, if present, would affect lamp performance adversely. The compensator is connected between the starter and one filament, and is out of circuit when the lamp is alight. The need for a compensator is much less marked in high-current lamps such as the British 5-ft. 80-watt lamp and the American 5-ft. 100-watt lamp. Opinion is divided as to its use in certain other ratings, and a final decision has not yet been made as regards the British 4-ft. 40-watt lamp.

Referring to Mr. Long's remarks, there may not be general agreement that the circuits shown in Figs. 8b and 9 are simpler than the normal starting switch circuit. The starter can be eliminated only by the use of larger and more costly auxiliary gear and usually at the cost of somewhat reduced overall luminous efficiency.

Mr. Long's comment about the visible line radiation from the mercury arc in fluorescent lamps is an interesting one. This radiation amounts to between 5 and 10 per cent. of the total visible radiation from the lamp. In practice the lines which affect colour rendering to any extent are those at 4047A and 4358A in the purple and blue, and it is probably true to say that their effect is only noticeable in warm-white lamps where there is little blue light from the fluorescent coating. In practice the colour distortion shows itself as a tendency to make certain blue colours look slightly purplish. Tungsten light equally distorts blue colours, but long usage has made this generally acceptable.

Replying to Mr. Vine, I would refer him to my remarks in reply to Mr. Long's comments on instant start gear. I agree that under low mains voltage conditions lamp stability is somewhat greater, with independent filament heating, but the essential simplicity of the starter-switch circuit has much to commend it. With regard to short lamps in series, we have had very good life performance with independent filament heating, and agree that the need for a starting strip is not so great.

On the question of earthing the strip, I do not see any problem in providing an earth for fluorescent lamp fittings in the same way as is done for other electrical equipment. I should view with considerable apprehension any method of earthing which involves connecting the fitting to the neutral of the supply system even through a high resistance and a small capacitor. It seems extremely unlikely that such a method would be tolerated on safety grounds.

Provisional Syllabus of Meetings

SESSION 1948-49

LONDON

1948

Oct. 12 *Sessional Meeting.* **Presidential Address** by J. M. WALDRAM. (*At the Royal Society of Arts, John Adam Street, W.C.2.*) 6 p.m.

Oct. 21 *Visit* to the Research Laboratories of the British Thomson Houston Company Limited, Rugby. (*The party will leave Euston Station at 10.50 a.m.*)

Nov. 9 *Sessional Meeting.* **High Speed Photography,** by J. W. MITCHELL. (*At the Lighting Service Bureau, 2, Savoy Hill, W.C.2.*) 6 p.m.

Nov. 23 *Visit* to Southampton Docks. (*The party will leave Waterloo Station at 9.30 a.m.*)

Dec. 8 *Informal Meeting.* Report and discussion on the 1948 meeting of the International Commission on Illumination. (*At Gas Industry House, 1, Grosvenor Place, S.W.1.*) 6 p.m.

Dec. 14 *Sessional Meeting.* **The Gas Arc—A New Light Source,** by J. N. ALDINGTON. (*At the Lighting Service Bureau, 2, Savoy Hill, W.C.2.*) 6 p.m.

1949

Jan. 11 *Sessional Meeting.* **Transport Vehicle Lighting** by H. R. RUFF, J. N. HULL, and R. V. MILLS. (*At the Lighting Service Bureau, 2, Savoy Hill, W.C.2.*) 6 p.m.

Jan. 26 *Informal Meeting.* Discussion on **Lighting in Coal Mines.** (*At Gas Industry House, 1, Grosvenor Place, S.W.1.*) 6 p.m.

Other meetings and visits, full details of which will be published later, are as follows:—

Sessional Meetings:—

Feb. 8
Mar. 8
April 12 } A number of papers of practical interest are being considered for presentation at these meetings.

May 10 **Annual General Meeting.**

Informal Meetings:—

Mar. 23 A discussion on **Lighting in other Countries.**

April 27 A discussion—**That Standardisation in Lighting Impedes Progress.**

Visits:—

Feb. *Visit* to a London Theatre to see the stage lighting.

April *Visit* to a glassworks.

It should be noted that *Sessional Meetings* are to be held on the second Tuesday of each month as in the past, but that *Informal Meetings* will be held on Wednesdays.

BATH AND BRISTOL CENTRE

(Unless otherwise stated all meetings will commence at 7 p.m.)

1948

Oct. 1 **Ship Lighting, with Special Reference to S.S. Caronia,** by T. CATTEN. (*At the Grand Hotel, Bristol.*) 5 p.m.

Nov. 5 **Decorative Design,** by J. ASSERSOHN, L. GARDINER, and H. WILSON. (*At the South Western Electricity Board, Old Bridge, Bath.*)

Dec. 3 **Glass in Projection Systems,** by E. H. WILLOTT. (*At the Grand Hotel, Bristol.*)

1949

Jan. 7 **Sports Lighting,** by D. E. BEARD. (*At the South Western Electricity Board, Old Bridge, Bath.*)

Feb. 4 **Transport Vehicle Lighting,** by H. R. RUFF. (*At the Grand Hotel, Bristol.*)

Mar. 4 **The Lighting of Architecture,** by G. GRENFELL BAINES. (*At the South Western Electricity Board, Old Bridge, Bath.*)

April 1 **Presidential Address,** by J. M. WALDRAM, and **Annual Dinner.** (*At the Grand Hotel, Bristol.*)

BIRMINGHAM CENTRE

(Unless otherwise stated meetings will be held at the Imperial Hotel, Temple Street, Birmingham, at 6 p.m. Tea buffet at 5.30 p.m.)

1948

Sept. 30 **"Ladies' Night."** Dinner Dance at the Crown and Cushion Hotel, Perry Barr, Birmingham.

Oct. 8 **Chairman's Address,** by J. H. NELSON.

Nov. 5 **Exhibition** of Lighting Equipment. (*At the Midland Electricity Board's Lecture Theatre, Paradise Street, Birmingham.*)

Dec. 3 **Maintenance of Fluorescent Lamps and Auxiliary Gear,** by W. A. R. STOYLE. (*Joint Meeting with the E.C.A. and A.S.E.E.*)

1949

Jan. 7 **Annual Dinner.**

Jan. 21 **Symposium of Papers,** by members of the Centre.

Feb. 25 **Annual General Meeting** and **Presidential Address** by J. M. WALDRAM.

Mar. 18 **Light as an Aid to Crime Detection,** by C. H. EDLIN.

April 8 **Seeing Conditions in Relation to Industrial Health,** by K. T. WATERS.

April 29 **Visit** to an Industrial Plant.

CARDIFF CENTRE

(Unless otherwise stated meetings will be held at the South Wales Institute of Engineers, Park Place, Cardiff, at 5.45 p.m.)

1948

Sept. 9 **Lighting of Docks and Railways,** by L. F. A. DRISCOLL.

Oct. 7 **General and Specialised Hospital Lighting,** by M. W. PEIRCE and D. J. REED.

Oct. 8 **Dinner and Dance.** (*At the Royal Hotel, Cardiff.*) 6.30 p.m.

Oct. 22 **The Educational Work of the E.A.W.,** by MISS VERA NORVIC. (*Joint meeting with E.A.W.*) 7 p.m.

Nov. 4 **Lighting in the Home—The Future Plan.** (*A discussion with the Newport Branch of the Electrical Association for Women and the Newport Townswomen's Guild. At the Newport Town Hall Assembly Room.*) 3 p.m.

Dec. 8 **The Manufacture of Tungsten Filament and Electric Discharge Lamps,** by S. G. TURNER and W. A. COOPER. (*Joint Meeting with the Mid-Glamorgan Scientific Society. At the Mining and Technical Institute, Cowbridge Road, Bridgend, Glam.*) 7 p.m.

1949

Jan. 6 **Presidential Address,** by J. M. WALDRAM.

Jan. 21 **The Manufacture of Tungsten Filament and Electric Discharge Lamps,** by S. G. TURNER and W. A. COOPER (lecture to Senior Students). (*At the Mining and Technical Institute, Cowbridge Road, Bridgend, Glam.*) 2.30 p.m.

Feb. 3 **High Speed Photography,** by J. W. MITCHELL.

Mar. 8, 9, and 10 **Lectures to Schoolchildren.** (*At Swansea.*) 10.30 a.m. and 2.30 p.m.

April 7 **High Voltage Lighting,** by C. DYKES-BROWN.

May 12 **Annual Luncheon** followed by **Annual General Meeting.** (*At the Royal Hotel, Cardiff.*) 12.30 p.m.

EDINBURGH CENTRE

(Unless otherwise stated meetings will be held at the Heriot-Watt College, Chambers Street, Edinburgh, at 6.30 p.m.

1948

Oct. 29 **Problems Associated with the Lighting of Departmental Stores,** by A. W. JERVIS.

Nov. 19 **Psychology of Good Lighting,** by C. J. KING.

Dec. 17 **Acrylic Plastics in Lighting,** by W. E. HARPER and H. P. WALKER.

1949

Jan. 28 **Electric Discharge Lamps for Floodlight Projection,** by H. W. CUMMING.

Feb. 25 **Black Light—Its Effect and Application,** by H. R. RUFF and H. L. PRIVETT.

Mar. 18 **Annual General Meeting and Dinner.** Visit by the President.

GLASGOW CENTRE

(Unless otherwise stated meetings will be held in the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, at 6.0 p.m.)

1948

Sept. 30 **Chairman's Address,** by D. Ross.

Oct. 28 **Problems Associated with the Lighting of Departmental Stores,** by A. W. JERVIS.

Nov. 25 **High Speed Photography,** by J. W. MITCHELL.

Dec. 16 **Acrylic Plastics in Lighting,** by W. E. HARPER and H. P. WALKER.

1949

Jan. 27 **Electric Discharge for Floodlighting Projection,** by H. W. CUMMING.

Feb. 24 **Black Light, Its Effects and Applications,** by H. R. RUFF and H. L. PRIVETT.

Mar. 17 **Annual General Meeting and Presidential Address,** by J. M. WALDRAM.

LEEDS CENTRE

(Meetings will be held at the No. 4 Sub Area Offices, Yorkshire Electricity Board, Whitehall Road, Leeds, 1, at 6 p.m.)

1948

Oct. 11 **Chairman's Address,** by J. D. GREEN.

Nov. 8 **Lighting of the R.M.S. Queen Elizabeth and the S.S. Caronia,** by T. CATTEN.

Dec. 13 **School Lighting,** by J. W. HOWELL.

1949

Jan. 10 **Problems night and informal discussion.**

Feb. 14 **Industry and Colour,** by J. H. NELSON.

Mar. 14 **Building Construction Methods in Relation to Lighting Installation Practice,** by R. H. WINDER.

April 11 **Annual General Meeting and Presidential Address,** by J. M. WALDRAM.

LEICESTER CENTRE

(Unless otherwise stated meetings will be held at the Demonstration Theatre of the East Midlands Electricity Board Charles Street, Leicester, at 6.30 p.m.)

1948

Oct. 14 **Light and Sight,** by HOWARD LONG.

Nov. 4 **Presidential Address,** by J. M. WALDRAM.

Dec. 9 **Office and School Lighting,** by F. JAMIESON.

1949

Jan. 13 **Architecture,** by J. H. Lloyd-Owen.
Feb. 10 **Church Lighting Systems,** by W. J. P. Watson.
Mar. 10 **Discussions evening.**
April 28 **Film evening.**
May 12 **Annual General Meeting and Smoking Concert.**

LIVERPOOL CENTRE

(Unless otherwise stated meetings will be held at the Lecture Theatre of the British Electricity Authority's Showroom, Whitechapel, Liverpool, 1, at 6.0 p.m.)

1948

Oct. 5 **Chairman's Address,** by O. C. Waygood.
Nov. 2 **Stage Illusion,** by M. G. Say. (*Joint Meeting with the British Drama League.*)
Dec. 7 **Mine Lighting,** by G. E. Chambers.

1949

Jan. 4 **Analysis of Lighting Problems in an Industrial Undertaking,** by F. G. Copland. (*Joint meeting with The Works' Managers Association, The Incorporated Plant Engineers and The Electrical Contractors Association.*)
Feb. 15 **New Lamp Developments,** by N. L. Harris. (*Joint meeting with the Institution of Electrical Engineers. At the Royal Institute, Colquitt Street, Liverpool.*)
Mar. 8 **Acrylic Plastics in Lighting,** by W. E. Harper and H. P. Walker. (*Joint meeting with the Association of Public Lighting Engineers.*)
April 5 **Glass in the Service of Light,** by A. J. Holland.

MANCHESTER CENTRE

(Unless otherwise stated meetings will be held at the Reynolds Hall, Manchester College of Technology, Sackville Street, Manchester, at 6 p.m.)

1948

Oct. 14 **Luncheon Meeting and Presidential Address,** by J. M. Waldram. (*At the Midland Hotel, Manchester.*) 12.30 p.m.
Colour, by W. J. Wellwood Ferguson. (*Joint meeting with the British Optical Association.*) 5.30 p.m.
Nov. 11 **Fluorescent Street Lighting,** by W. D. Sinclair. (*Joint meeting with the A.P.L.E.*)
Dec. 9 **Film Studio Lighting,** by F. V. Hauser, F. S. Hawkins, and W. R. Stevens. (*Joint meeting with the Royal Photographic Society and the Manchester Amateur Photographic Society.*)

1949

Jan. 13 **Open Forum.** A panel of experts ans wering questions.
Feb. 10 **Lighting of Architecture,** by G. Grenfell Baines.
Mar. 10 **Acrylic Plastics in Lighting,** by W. E. Harper and H. P. Walker.
April 14 **New Developments in Fluorescent Lighting,** by J. W. T. Strange. (*Joint meeting with the Institution of Electronics.*)

NEWCASTLE CENTRE

Unless otherwise stated meetings will be held in the Minor Durant Hall, Oxford Street, Newcastle-upon-Tyne, at 6.15 p.m.)

1948

Oct. 6 **Chairman's Address,** by H. L. James.
Nov. 3 **Illumination of Architecture,** by G. Grenfell Baines.
Dec. 1 **Some Unusual Lighting Installations,** by W. A. Dodgson.

1949

Jan. 12 **Annual Dinner and President's Visit.**
Feb. 2 **Application of Modern Flash Discharge Tubes,** by C. R. Bicknell.
Mar. 2 **The Application of Polarized Light,** by J. Ward.
April 6 **Annual General Meeting.**
Maintenance of Lighting Equipment and Installations, by R. P. Wingate.

NOTTINGHAM CENTRE

(Unless otherwise stated all meetings will be held in the City of Nottingham Gas Department Demonstration Theatre, Parliament Street, Nottingham, at 5.30 p.m.)

1948

Oct. 1 **Rainbow Magic,** by H. R. Ruff. (*Joint meeting with the E.A.W.*)
Nov. 5 **Presidential Address,** by J. M. Waldram.
Dec. 3 **Lighting of Coal Mines,** by P. L. Ross and F. Widnall. (*Joint meeting with the Association of Mining, Electrical and Mechanical Engineers.*)

1949.

Jan. 7 **Lighting of Trains and Public Service Vehicles,** by S. Anderson and C. D. Brown.
Feb. 4 **Acrylic Plastics in Lighting,** by W. E. Harper and H. P. Walker.
Mar. 4 **Lighting of Large Retail Stores,** by A. W. Jervis. (*Joint meeting with E.C.A.*)

SHEFFIELD CENTRE

Unless otherwise stated meetings will be held in the Medical Library, The University, Western Bank, Sheffield, 10, at 6 p.m.)

1948

Oct. 4 **Lighting in the S.S. Caronia,** by T. CATTEN.
Nov. 1 **Church Lighting,** by W. T. SOUTER.
Dec. 6 **Organisation of Electricity Supply to the City of Sheffield,** by A. HADDOCK. (*Joint meeting with he E.C.A. and E.A.W.*)

1949

Jan. 4 **"Rainbow Magic,"** by H. R. RUFF. (*At the Technical College, Bow Street, Sheffield.*)
Feb. 7 **Store and Display Lighting,** by D. C. JAMES.
Mar. 7 **The Place of Science in the Art of Lighting,** by R. O. ACKERLEY and ALISTER MACDONALD.
April 25 **Annual General Meeting and Presidential Address.**

BRADFORD GROUP

(Meetings will be held in the Bradford No. 1 Sub Area Office of the Yorkshire Electricity Board, 45–53, Sunbridge Road, Bradford, at 7.30 p.m.)

1948

Sept. 30 **Operation and Maintenance of Fluorescent Tubes,** by W. A. R. STOYLE.
Oct. 28 **School Lighting,** by P. H. HARRIS.
Nov. 25 **Lighting of Recreational Centres,** by A. WILCOCK.
Dec. 16 **The Latest in Electric Lamps,** by H. L. PRIVETT.

1949

Jan. 13 **High Voltage Fluorescent Tubes,** by J. N. BOWTELL.
Feb. 10 **Glass in the Service of Light,** by A. J. HOLLAND.
Mar. 10 **Television,** by J. T. THORNTON.

EXETER GROUP

1948

Sept. 30 **Ship Lighting, with Special Reference to S.S. Caronia,** by T. CATTEN.
Nov. 4 **Decorative Design,** by J. ASSERSOHN, L. GARDINER, H. WILSON.
Dec. 2 **Glass in Projection Systems,** by W. H. WILLOTT.

1949

Jan. 6 **Sports Lighting,** D. E. BEARD.
Feb. 3 **Transport Vehicle Lighting,** by H. R. RUFF
Mar. 3 **The Lighting of Architecture,** by G. GRENFELL BAINES.

HUDDERSFIELD GROUP

(Unless otherwise stated meetings will be held at the Electricity Showroom, Market Street, Huddersfield, at 7.15 p.m.)

1948

Oct. 8 **Lighting and Safety in Factories,** by L. C. RETTIG.
Nov. 5 **Glare and Natural Lighting,** by W. A. ALLEN.
Dec. 3 **Light and Colour on the Stage,** by P. CORRY.
Dec. 7 and 8 **Lectures to Schoolchildren.** (*At the Large Hall, Technical College, Queen Street South, Huddersfield.*) (Dates subject to confirmation.)

1949

Jan. 7 **Modern Ideas on Shiplighting,** by T. CATTEN.
Feb. 4 **Open Discussion.**
Mar. 4 **The Operation and Maintenance of Fluorescent Lamp Installations,** by W. A. R. STOYLE.
April 8 **Lighting in the Textile Industry,** by T. S. JONES.
April 29 **Film evening and Annual General Meeting.**

TEES-SIDE GROUP

(All meetings will be held in the Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, at 6.15 p.m.)

1948

Oct. 13 **Operation and Maintenance of Fluorescent Lamp Installations,** by W. A. R. STOYLE.
Nov. 17 **Chairman's Address,** by N. HUNTER.
Dec. 22 **Technical Films of General Interest,** by N. HUNTER.

1949

Jan. 19 **Mine Lighting,** by C. E. CHAMBERS.
Feb. 16 (Details to be arranged.)
Mar. 16 **High Brightness Mercury and Mercury-Cadmium Sources,** by E. J. G. BEESON.

Obituary

JOHN STEWART DOW

The news of the passing of John Stewart Dow on August 12 after a very short illness will be received with more than ordinary regret by the large proportion of members of the Illuminating Engineering Society to whom he was known personally. To those who have worked more closely with him—and how many are in this category—the feeling is that of losing a friend, one of those outstanding characters who can ill be spared.

From the very beginning of his career, immediately after his training at the City and Guilds Technical College, Dow was associated with the physical aspects of light and, while a demonstrator at the college, he paid particular attention to photometric and other work in the Light Laboratory, later carrying out some experimental work on the Purkinje effect and on a design for a Cosine Flicker Photometer.

From 1907 Dow worked with the late Leon Gaster, who was at that time a Consulting Electrical Engineer dealing particularly with electric lighting developments. In 1908, when Gaster started the *Illuminating Engineer* as propaganda for the new movement in illuminating engineering, Dow acted as Assistant Editor, though really doing all the journalistic work. He continued to be the prime mover of the magazine right up to the time of his death.

In 1909 the Illuminating Engineering Society was founded and for many years was run almost entirely by Gaster and Dow, and it is interesting to recall that they both attended all meetings of Council and all committees up till the time of Gaster's death in January, 1928. From that time onwards Dow became the Honorary Secretary of the Society and Editor of the journal, both of which tasks he had virtually been undertaking for some time previously.

Throughout the early days of the Society whilst Leon Gaster by his enthusiasm and driving personality was getting the movement recognised, the quiet steady work behind the scenes was being done by Dow. It was remarkable team work, and those who were privileged to know both these personalities will recollect how much of the inspiration came from Gaster, but how his enthusiasm had to be tempered by his assistant to whom most of the organising and steady development were due.

In 1910, Dow, in association with V. H. Mackinney, developed the idea of an illumination photometer which eventually took practical shape in the Holophane Lumeter. This apparatus held the field for some time and was the means of collecting an immense amount of data concerning illumination values in schools, libraries, railway-stations, etc. Factory lighting was one of the fields especially emphasised in the literature of the Society, and Dow was a member of the Departmental Committee on Factory Lighting (under the chairmanship of the late Sir Duncan Wilson) whose recommendations on lighting were ultimately embodied in the Factory Act of 1941.

During the period of the first World War, although the work of the Society and the publication of the Journal continued more or less without interruption, Dow was called upon to assist in experimental work on the effect of flares and verey lights and carried out many illumination tests at the trial ground in South London.

The rapid development of the Society during the last 15 years, the expansion of provincial centres and the large amount of detail involved, laid a heavy burden on the hon. Secretary. Throughout this period, however, Dow's

patience and tact and his remarkable gift for ensuring amicable working on committees where views were sometimes inclined to be strongly at variance, contributed largely to the progress that has been made. It was in recognition of his outstanding work that he was elected an honorary life member in 1942. This honour and the presentation made to him at the I.E.S. Convention in 1946 (when he retired from the position of Hon. Secretary and was nominated President for 1946-7) were occasions he looked back on with great, but almost secret, pride.

Dow's contributions to the literature on illuminating engineering were naturally extensive. The part he took in the discussions of the I.E.S. will be remembered by all, not only for the value of the ideas expressed but for the easy charm of manner in which his thoughts were conveyed. Furthermore, his wide experience of many fields of illumination enabled him to bring a shrewd judgment to bear on any new problems, and rendered his remarks more valuable. Among his larger works was the volume on "Modern Illuminants and Illuminating Engineering," published in 1915, in which he collaborated with Leon Gaster, and a more recent booklet entitled "Light In Daily Life."

His interests extended far beyond the field of illuminating engineering, although this was always foremost in his thought and action. An enthusiastic gardener in his spare time, he was a member of the Royal Horticultural Society, and had drawn a parallel between that Society and the I.E.S. in his recent presidential address. He had a great love of natural beauty and immensely enjoyed walks in the country, occasionally perhaps stretching the capacity of his fellow-walkers. In his younger days he took some share in sport—mainly hockey—and indulged in rock climbing to a limited extent. He was also a keen stamp-collector.

Although Dow may be regarded as one of the chief architects of the illuminating engineering movement in this country, it is as a man of unusual personal characteristics that most of us will remember him. His natural courtesy and charm of manner endeared him to all, but his modesty tended to hide some of the finer traits appreciated by those who knew him more intimately. In describing the desirable cultural background for members of the Society in his recent presidential address, he used the following phrase:—

"Not merely ease of manner and grace of manner—though certainly these are valuable gifts—but rather that instinctive feeling which enables some people to express disagreement without giving offence and to correct without giving pain or causing humiliation."

Were these qualities not exemplified to the full in the late J. S. Dow?

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

With a view to avoiding possible confusion with other publications, reference to these Transactions should be in the form:—"Trans. Illum. Eng. Soc. (London)."

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